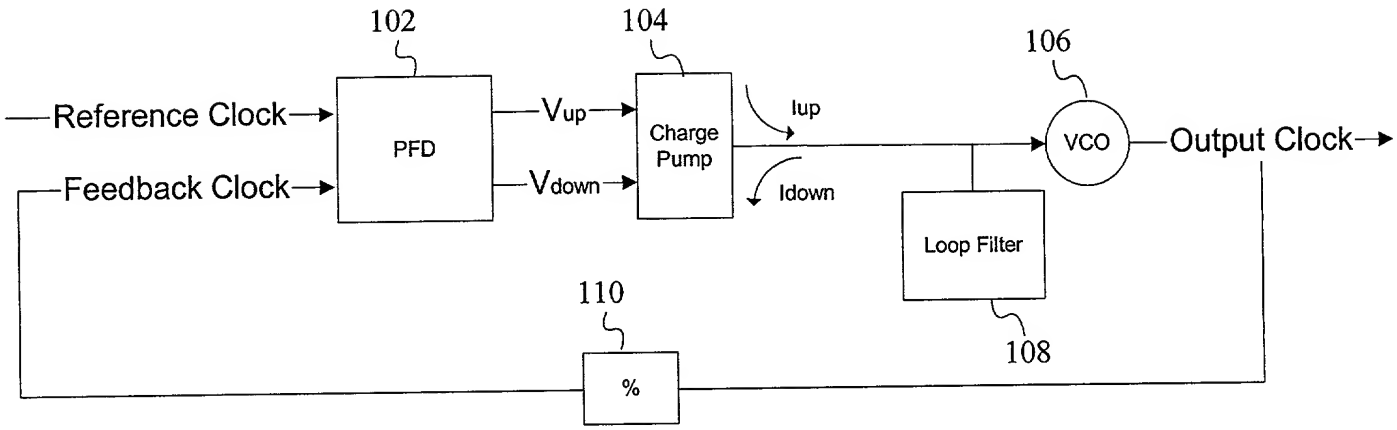


Figure 1A

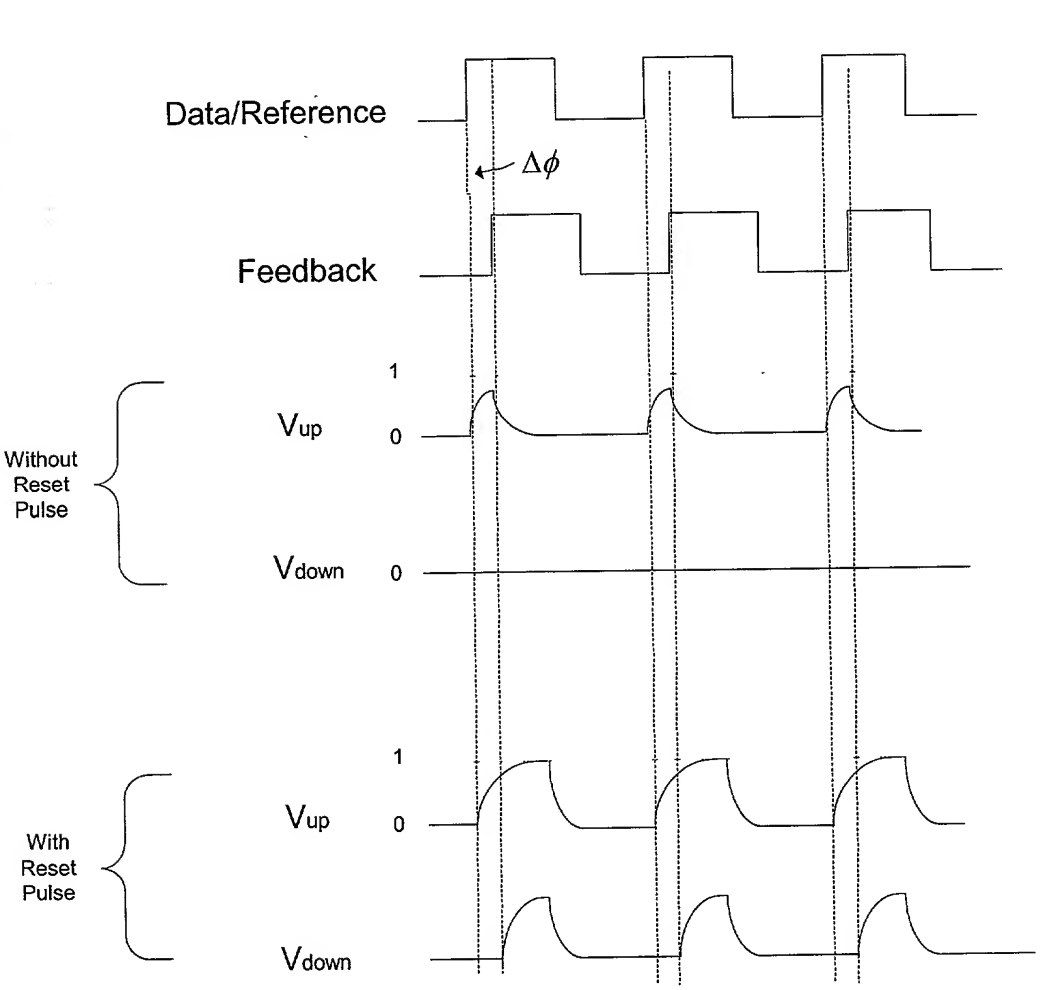
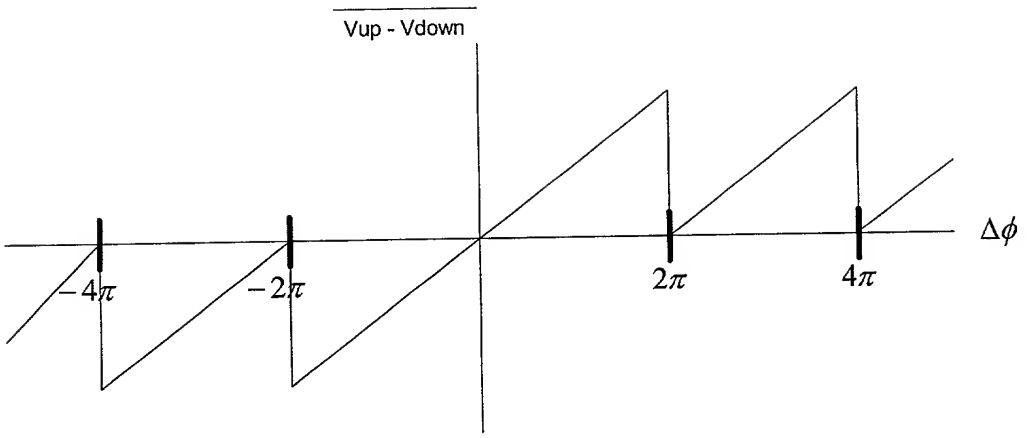
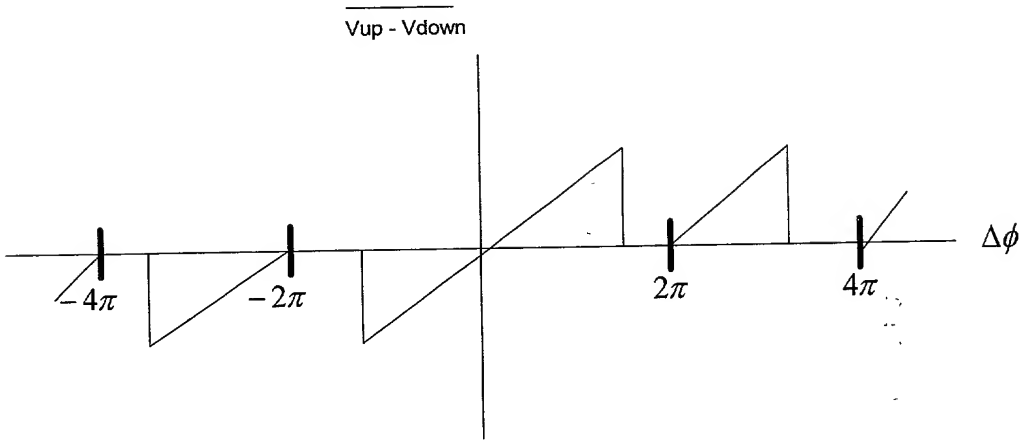


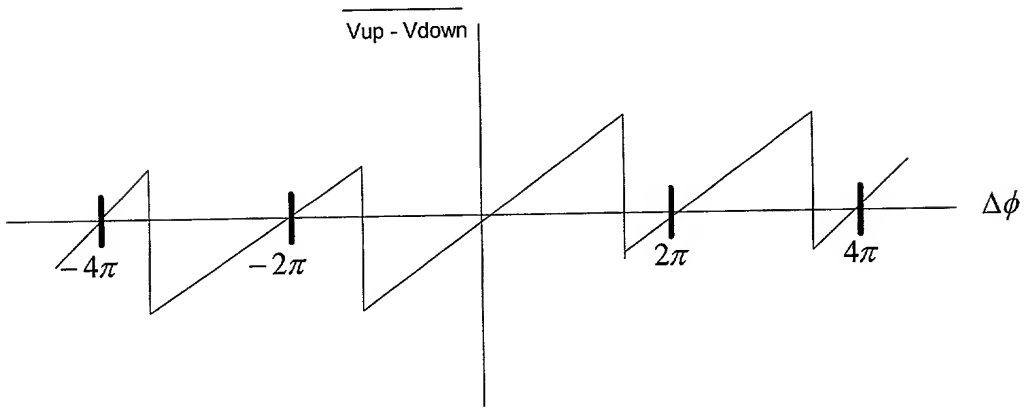
Figure 1B



Ideal PFD



PFD with dead zone



PFD with finite pulse width

Figure 1C

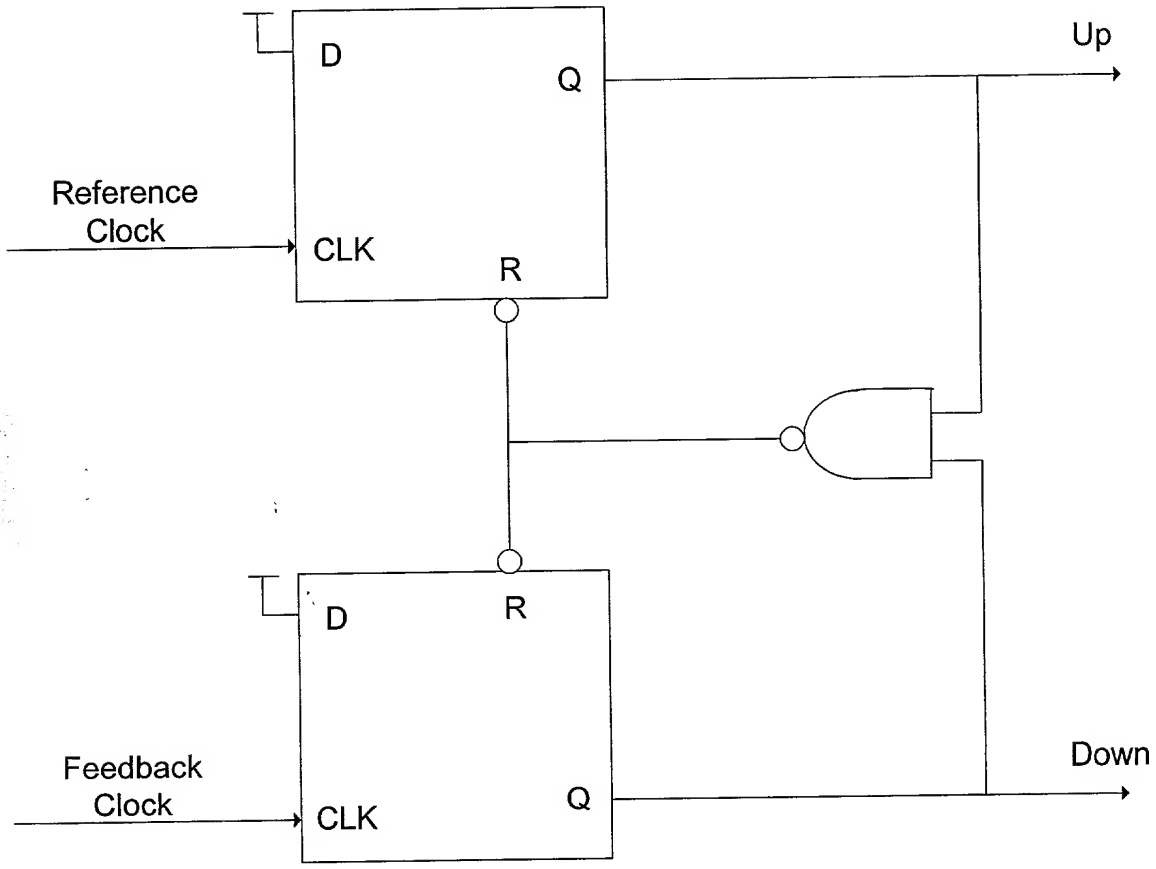


Figure 1D

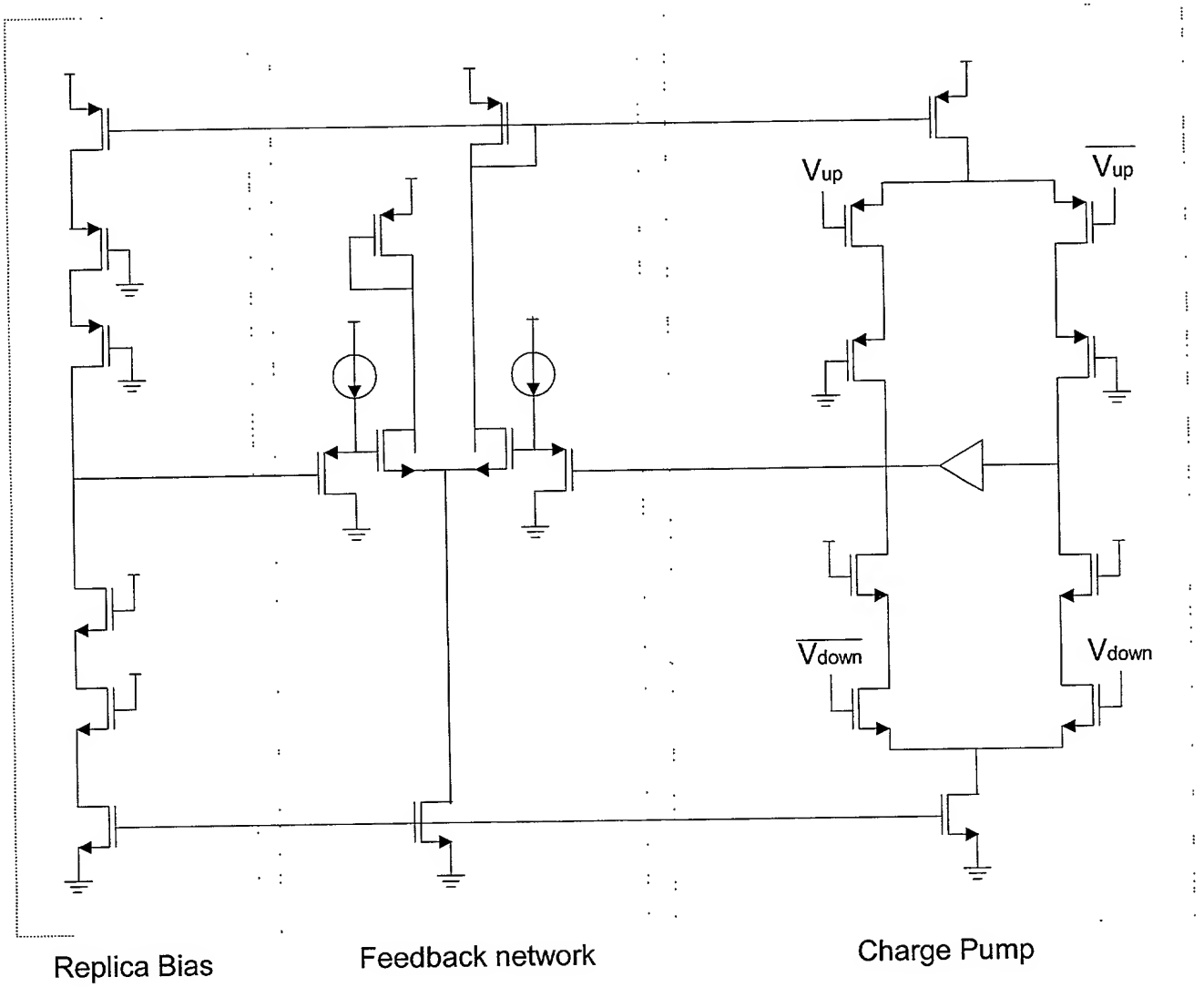

Vup
Vup
Vdown
Vdown
Replica Bias
Feedback network
Charge Pump

Figure 1E

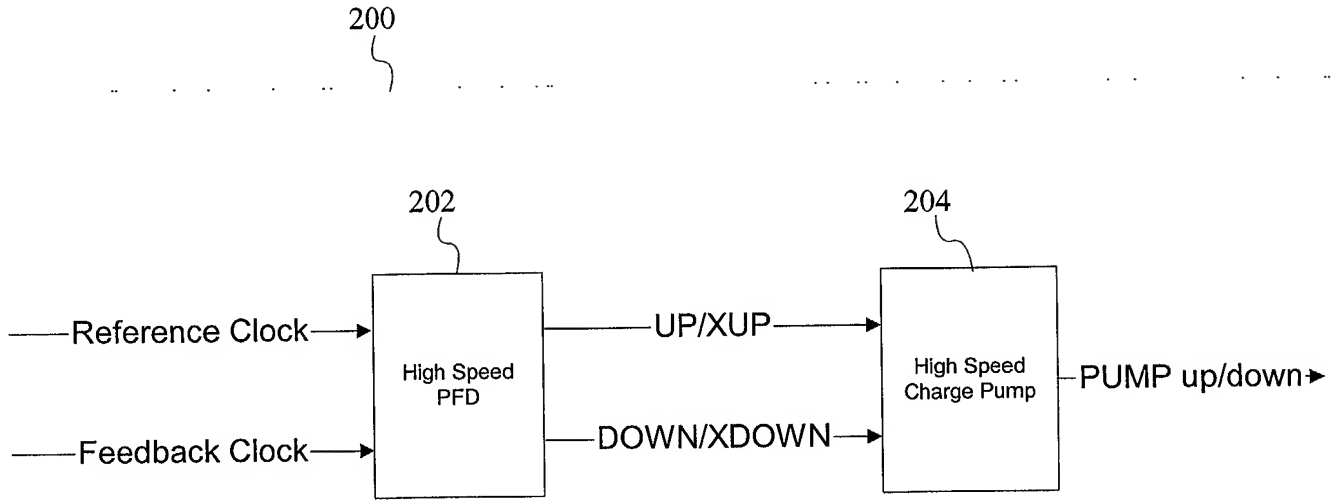

200
202
204
Reference Clock
Feedback Clock
High Speed PFD
UP/XUP
DOWN/XDOWN
High Speed Charge Pump
PUMP up/down

Figure 2

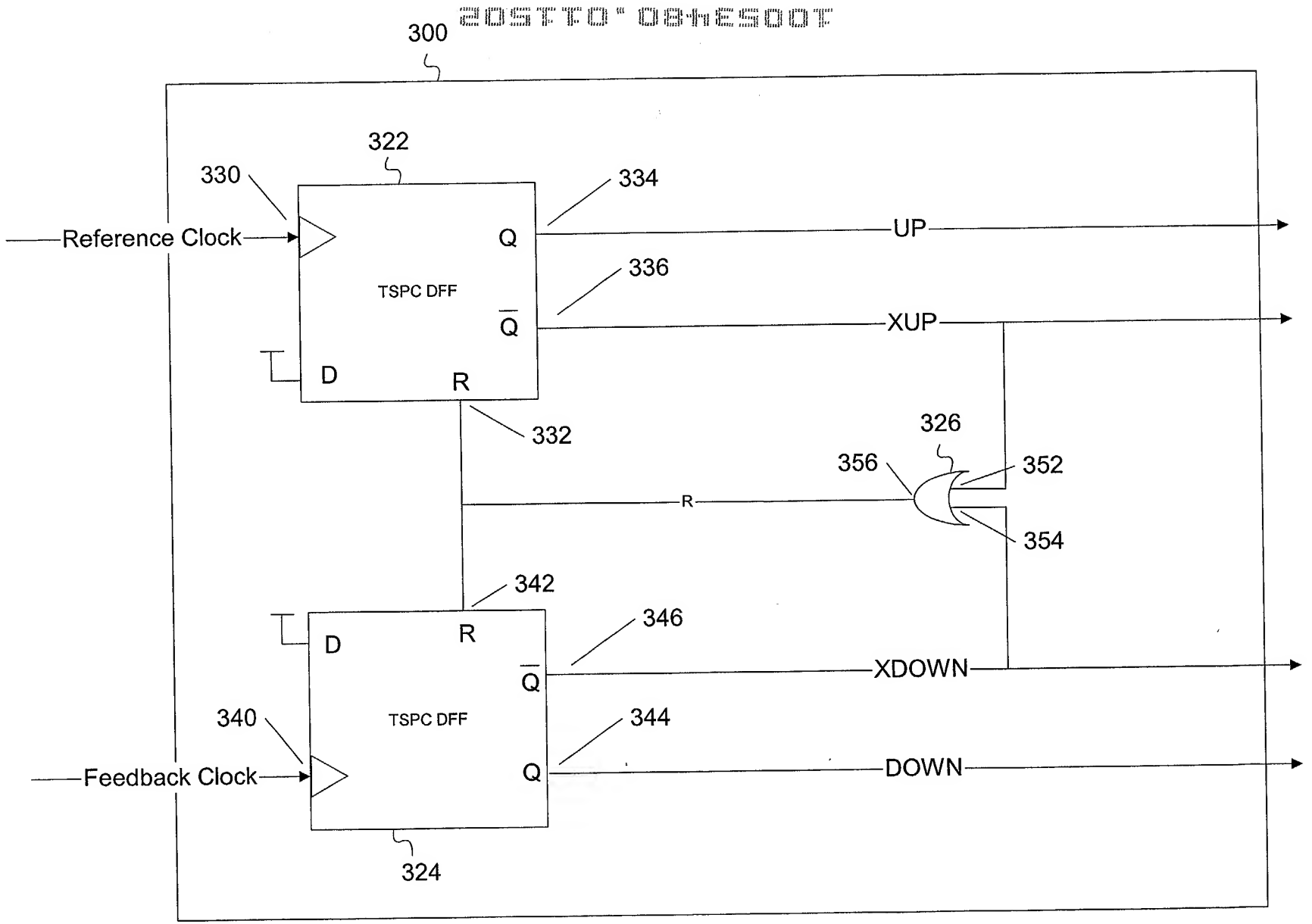

300
322
330
334
Reference Clock
Q
UP
TSPC DFF
336
$\overline{Q}$
XUP
D
R
332
326
356
352
R
354
342
D
R
346
$\overline{Q}$
XDOWN
340
TSPC DFF
344
Feedback Clock
Q
DOWN
324

Figure 3

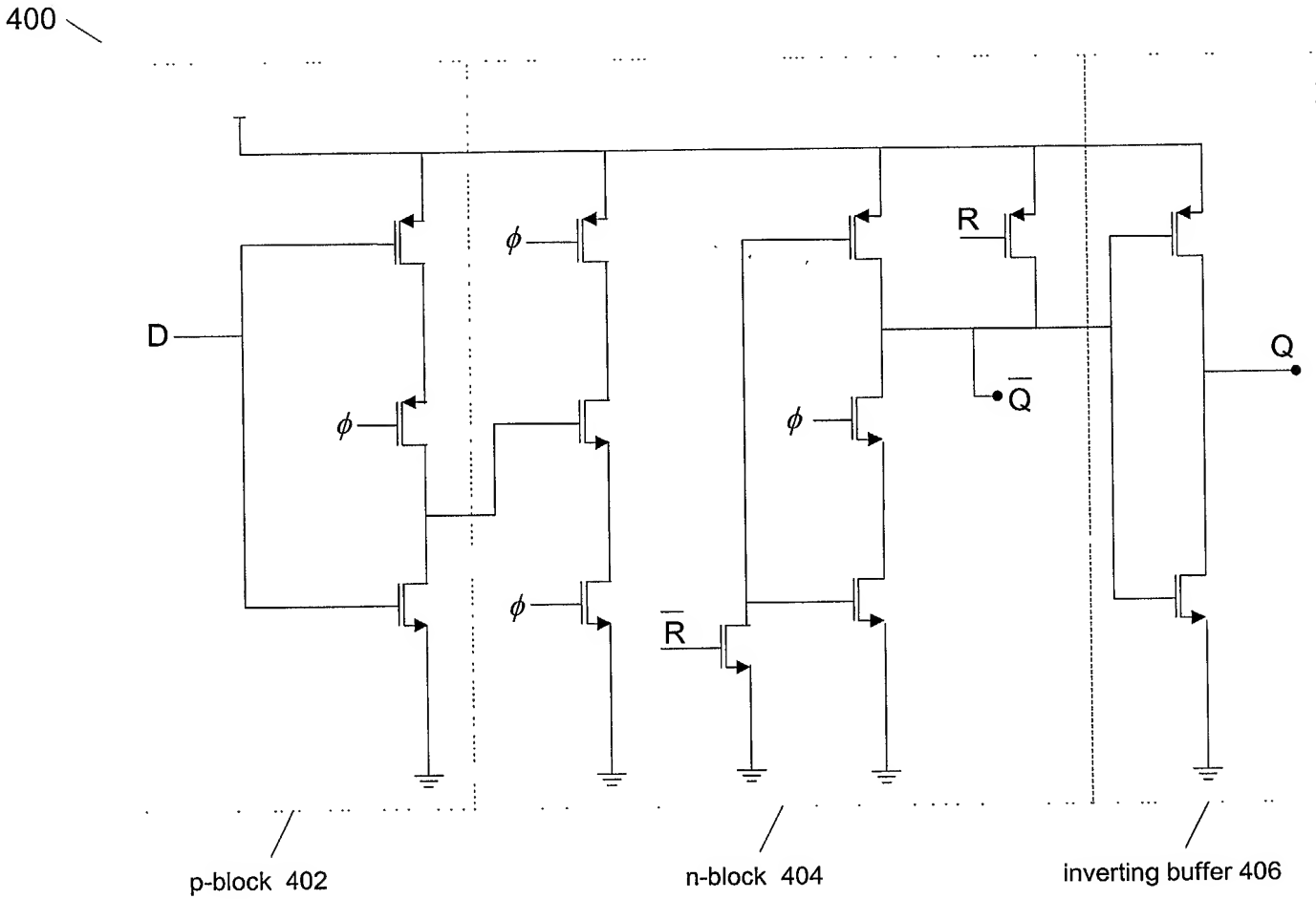


Figure 4

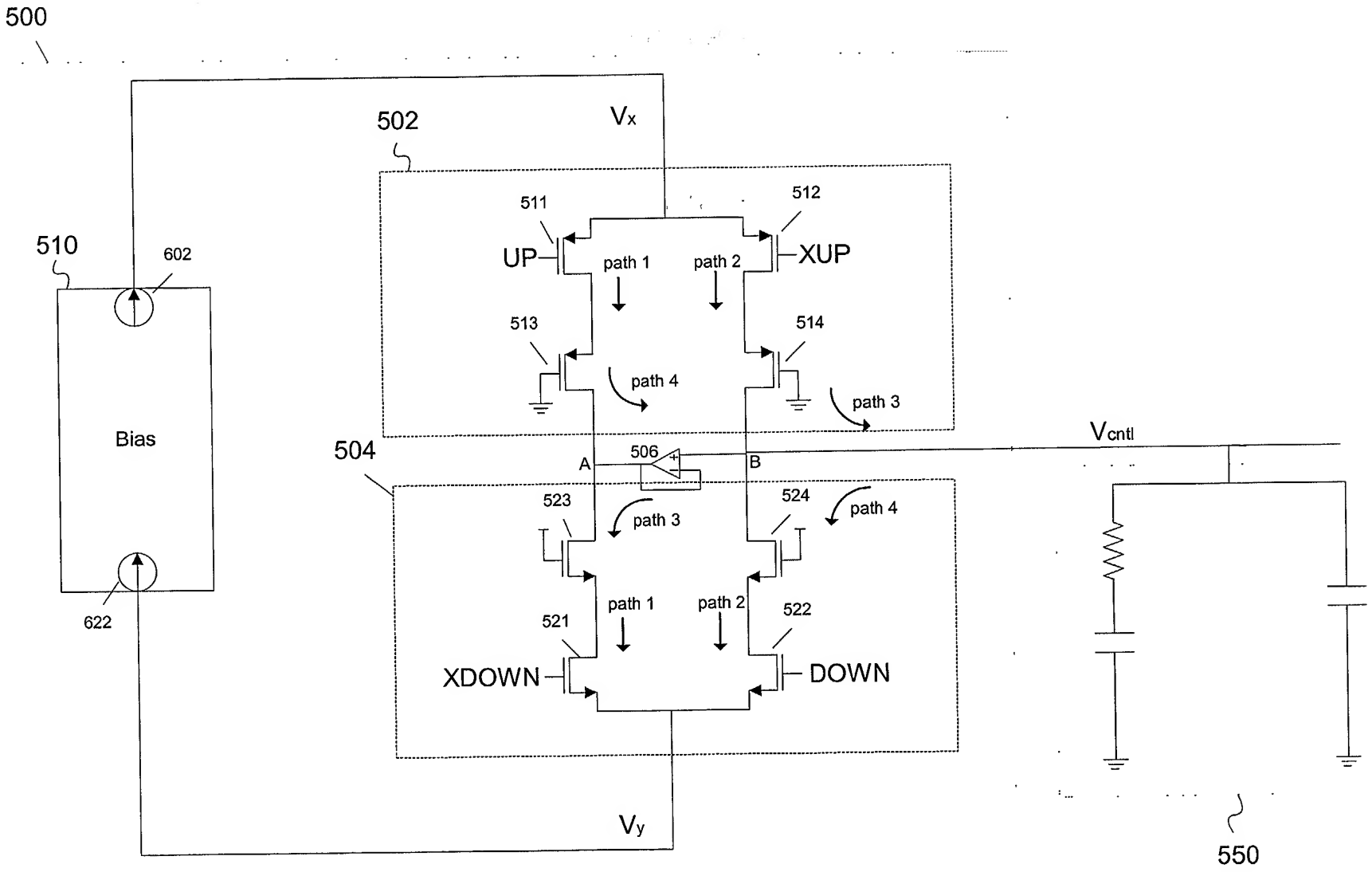
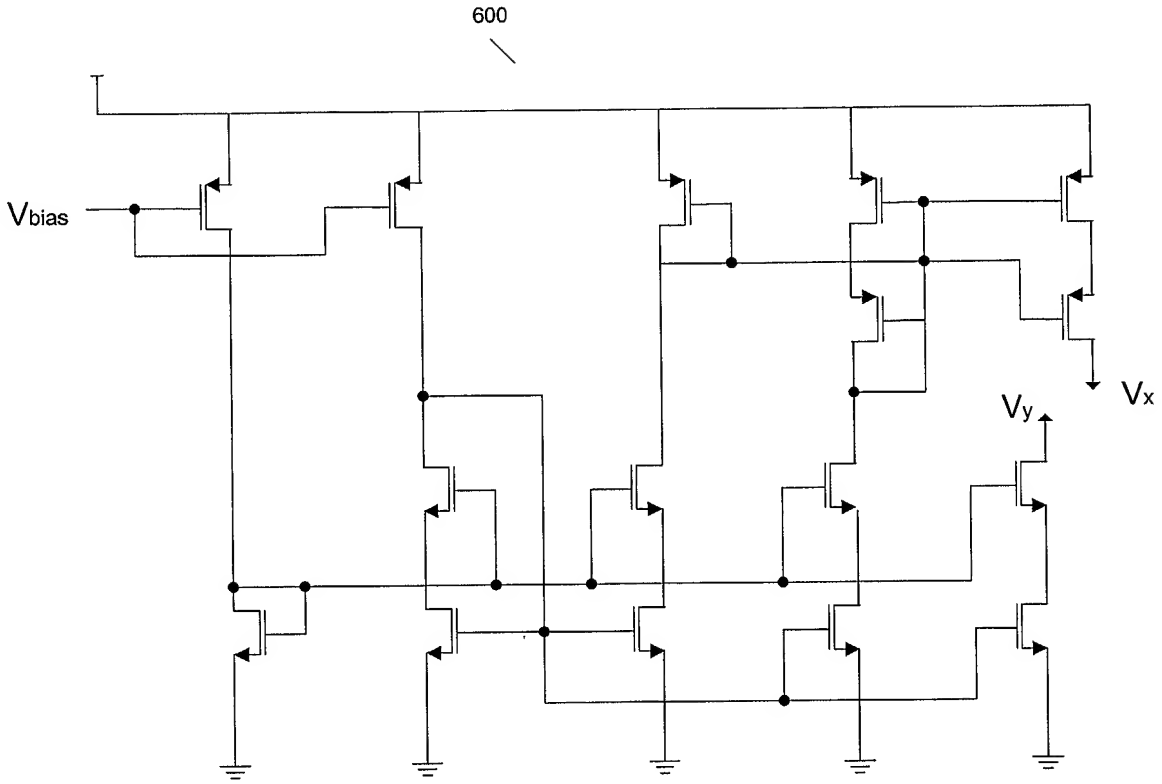


Figure 5



R

Figure 6

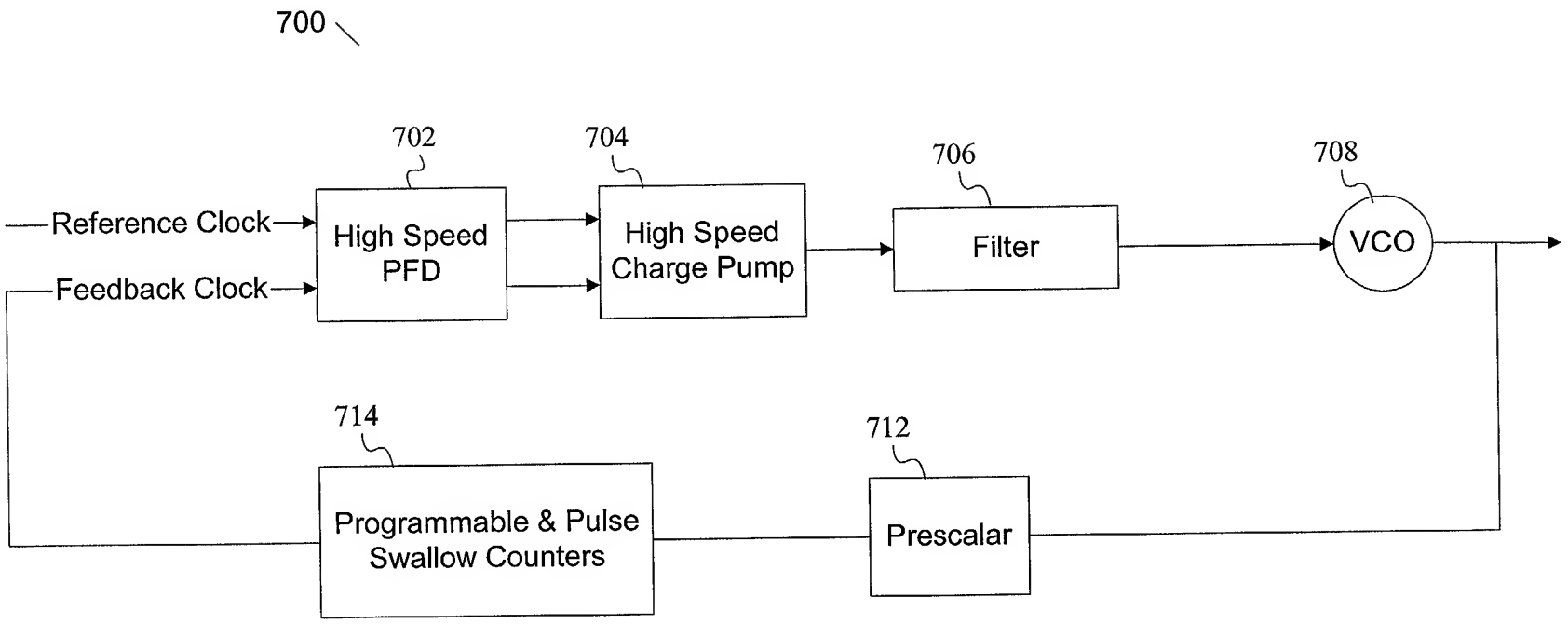


Figure 7